1987

REPORT ON

BRIDGE DECK

WATERPROOFING

B Y

R.C.EVERS
D.F.LYNCH

BITUMINOUS SECTION
ENGINEERING MATERIALS OFFICE

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SUMMARY

In 1987, the Ministry of Transportation monitored the thickness of waterproofing membrane placed on bridges under its authority as well as the quality of the membrane.

Membrane thickness is controlled by an end result specification (ERS) which was introduced in 1986. This specification was expanded in 1987 to include membrane quality.

This report contains a summary of the data assembled and comments on the level of compliance with specified tolerances.

Problems with field personnel filling out Waterproofing Membrane Thickness Report forms and Concrete Product Field Sample Sheets are discussed.

As a result of an analysis of the contained data, it is concluded that membrane thickness and quality compliance is continuing to improve under end result specifications.

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1 INTRODUCTION

1.1 Material Thickness

In 1987, the Bituminous Section of the Engineering Materials Office received 254 waterproofing thickness reports representing 90,900 m^2 of waterproofing. Each report was checked for completeness and accuracy and the data then entered on a micro computer spreadsheet. The micro computer was used to sort, analyze and graphically depict the accumulated data.

1.2 Material Quality

The Concrete Section of the Engineering Materials Office tested 158 samples of hot applied rubberized asphalt membrane waterproofing in 1987. These samples represent products from five manufacturers as submitted from contract job sites. The samples were obtained from the contractor's melting kettle so as to be representative of what was placed on the bridge deck. The test results were also entered on a micro computer spread sheet program.

The samples were tested for compliance with six specification requirements:

1.	Cone Penetration	@ 25°C	max.	110
2.	Cone Penetration	@ 50°C	max.	160
3.	Flow	@ 60°C	max.	4
4.	Low Temperature Flexibility	@ -25°C		Pass
5.	Toughness		min.	5.5
6.	Toughness/Peak Load Ratio		min.	0.004

2 DATA ANALYSIS

2.1 Material Thickness

Of the 254 lots reported, 16 were borderline and 4 were rejectable. (Refer to Provincial Highways report EM-79 for acceptance criteria.) Not all contracts contained the special provision providing for price adjustment or rejection based on statistical sampling. As a result, only 13 of the 16 borderline lots received price adjustment and only two of the four rejectable lots were actually rejected. The contractor repaired one rejectable lot selectively by identifying areas of thin membrane, removing the protection boards, applying additional membrane and installing new protection boards. The other rejectable lot was repaired by complete removal of the system and reconstruction.

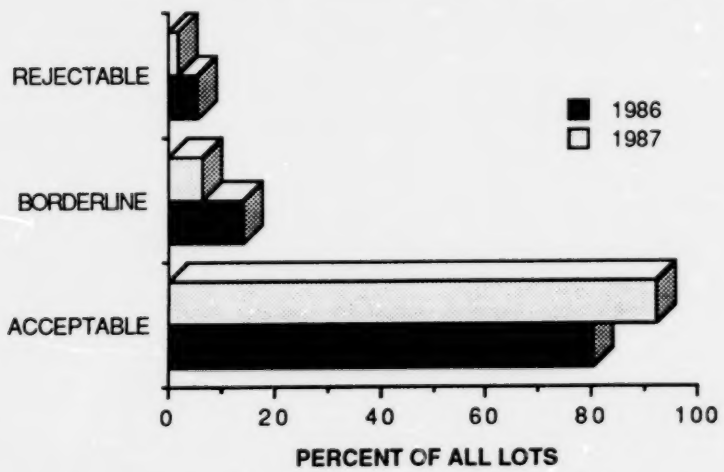
The overall quality of membrane installation improved in 1987 over 1986 with a reduction in the average lot standard deviation. In fact, the overall quality has improved each year since 1983 when the interim "End Result" acceptance plan was introduced. Table I summarizes the lot statistics for years 1984 to 1987.

TABLE 1: MEMBRANE THICKNESS IMPROVEMENT

YEAR	NO. OF LOTS	MEAN THICK. (mm)	AVG. LOT ST. DEV.
1984	261	4.7	0.75
1985	306	4.8	-
1986	157	4.9	0.70
1987	254	4.9	0.63

In 1986, close to 80% of all lots constructed were acceptable, improving to 97% in 1987. Figure I depicts the improvement in the form of bar charts.

FIG.1 : MEMBRANE THICKNESS BY LOTS



Ten contractors shared the work in 1987 with one contractor getting the lion's share of the work (47% of the lots constructed). Figure 2 demonstrates how the work was divided between the contractors. Of the ten contractors, four had all lots accepted at full price and six had some borderline or rejectable lots. Figure 3 depicts how each contractor performed (identities concealed).

FIG.2 : CONTRACTORS SHARE OF LOTS

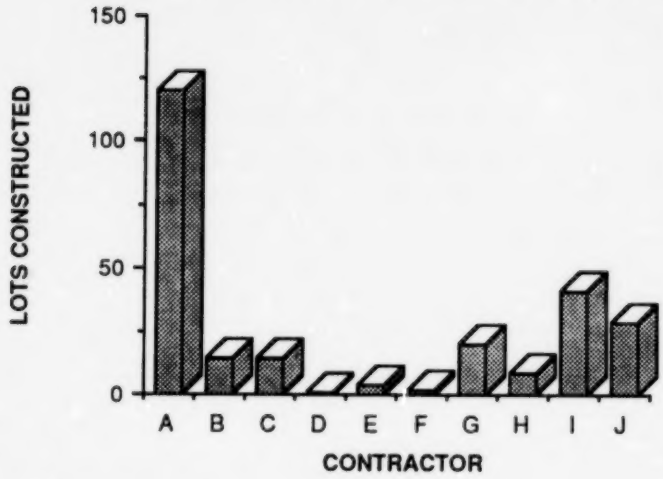
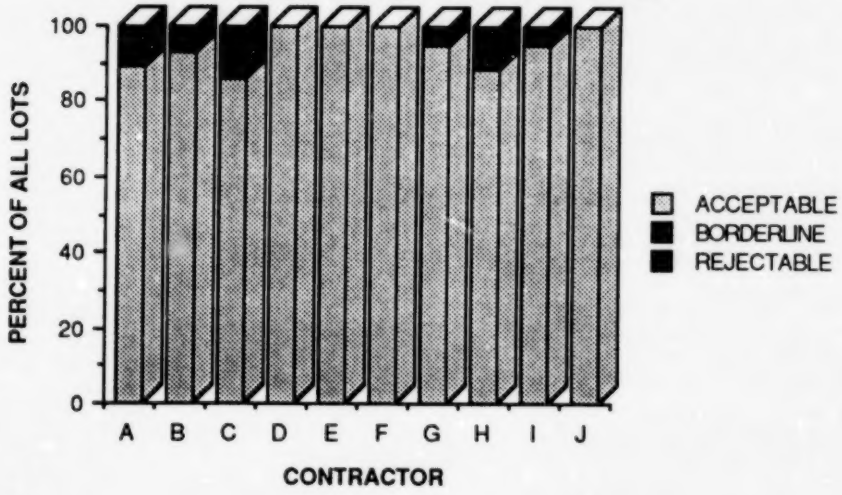


FIG.3 : CONTRACTOR PERFORMANCE

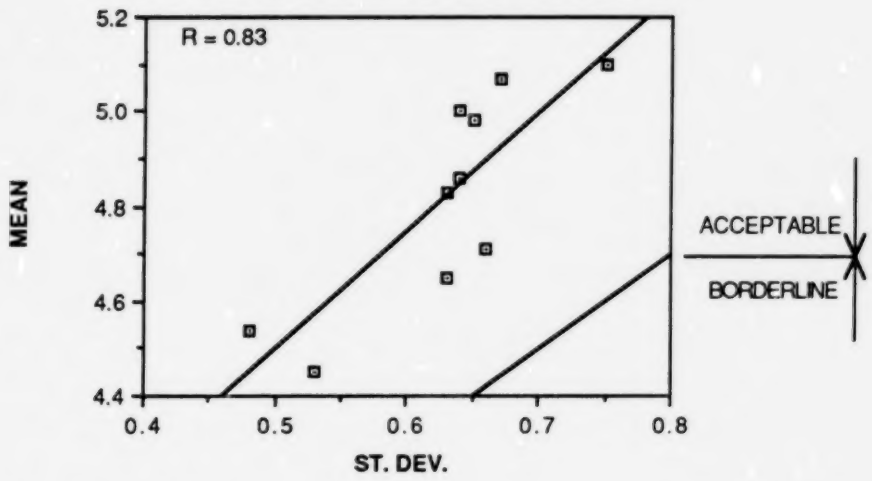


Individual contractor statistics are presented in Table 2. From Table 2 it would appear that contractors achieving lower standard deviations (better process control) are able to save on material by applying a uniformly thinner membrane. A plot of the average standard deviation vs. the mean thickness achieved by each contractor supports this observation (Fig. 4). It may be seen that the best-fit line with a correlation coefficient of 0.83 suggests there is a definite relationship between these two variables. The oblique line in the lower right corner of Fig. 4 delineates the boundary between acceptable and borderline lots.

TABLE 2 : CONTRACTORS' STATISTICS

CONTRACTOR	MEAN THICKNESS	AVERAGE LOT ST. DEV.
A	4.98	0.65
B	4.71	0.66
C	4.86	0.64
D	5.10	0.75
E	4.65	0.63
F	4.45	0.53
G	5.07	0.67
H	4.83	0.63
I	5.00	0.64
J	4.54	0.48

FIG.4 : ST. DEV. vs MEAN THICKNESS



2.2 Material Quality

Eighty of the 158 samples tested were from one manufacturer, with four other suppliers sharing the balance. Figure 5 demonstrates the distribution of the samples tested by the Ministry. Eighty percent of the samples met all test criteria with 20% failing one or more tests. Figures 6 and 7 demonstrate the proportions of samples failing tests.

FIG.5 : MANUFACTURER OF PRODUCTS TESTED

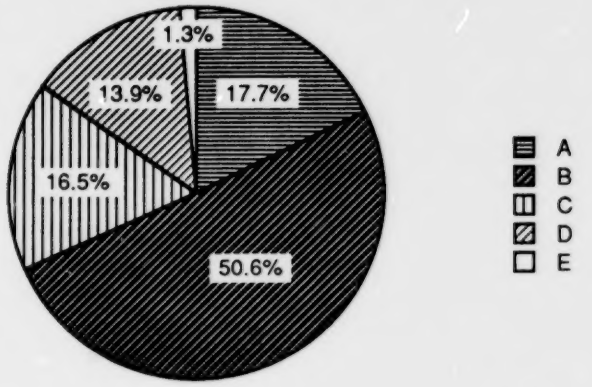


FIG.6 : ASPHALT MEMBRANE QUALITY TESTS

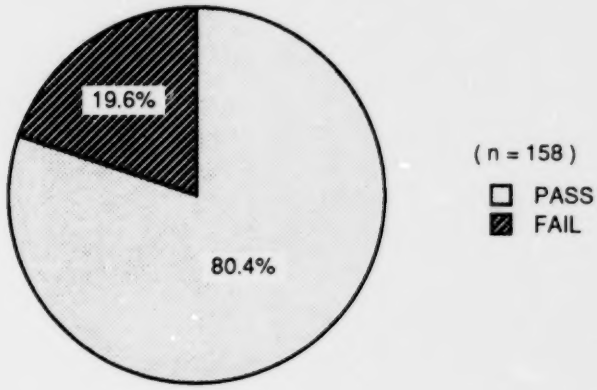
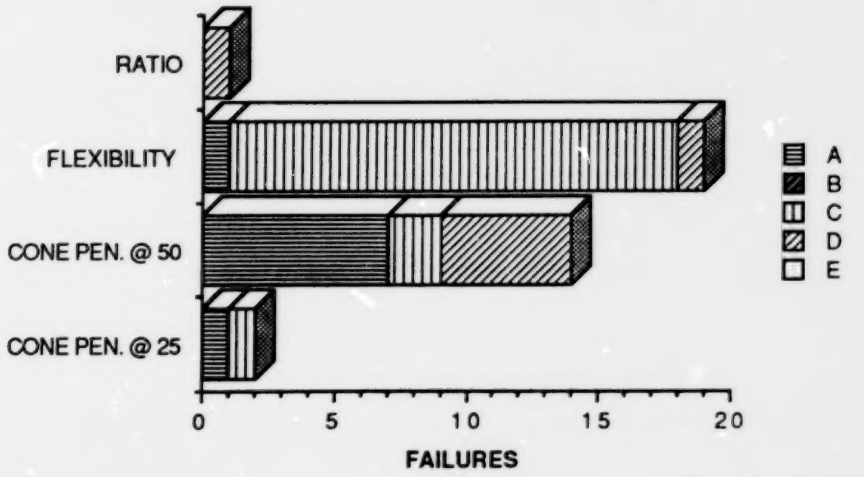


FIG.7 : TEST CRITERIA FAILED



Material manufactured by the major supplier of membrane to the Ministry passed all quality tests ("B" FIG.5) .

A moratorium on the supply of products to the Ministry by manufacturers "A" and "C" was put in force after several samples failed quality tests. These products were reapproved after the manufacturers assured the Ministry that quality problems had been resolved. No subsequent samples from these two manufacturers failed any tests.

Manufacturer "D" had several sample failures and a meeting with Ministry officials was arranged. After this meeting, no subsequent samples failed.

Although not a specification requirement, the mass density of each sample is determined in the laboratory. This mass density along with the other tests can be used to ascertain whether the sample is representative of the material as identified on the sample sheet. Since the various products have different mass densities, it is a useful tool to determine if a sample has been adulterated.

From the mass density of each product, the quantity required to cover a given area may be determined. Table 3 presents the quantity of product required to cover a square metre with 5 mm of membrane based on the mean mass density determinations of the five products supplied to the Ministry in 1987.

TABLE 3 : MATERIAL REQUIRED PER SQUARE METRE OF BRIDGE DECK (5 mm thick)

PRODUCT	kg/m^2
BAKELITE 790-11	6.60
BE-RAM BEMALASTIC	7.75
GLOBE W1-250	6.25
HYDROTECH 6120	6.10
W.R. MEADOWS L-73-R	5.88

3 DISCUSSION

3.1 Material Thickness

When the statistical acceptance system involving price adjustment for thickness was first introduced, it was said by some contractors to be too restrictive or even unattainable.

The high level of compliance in 1987 (92% of all lots receiving full payment) demonstrates that contractors can work to the requirements of the acceptance system. The percent compliance will likely improve in 1988 with the contractors gaining experience in exercising process control.

When the statistical acceptance system involving price adjustment for thickness was first introduced, waterproofing contractors were concerned the rough surface on some older bridges would adversely affect their chances of full payment even with excellent process control.

The Ministry made a commitment to improve the surface of a rough existing deck or waive the statistical acceptance with price adjustment in favour of acceptance based on a mean thickness only.

Over the last two years there have been a few decks where Ministry staff have employed the price adjustment system and the contractor has claimed it should not have been applied due to excessive roughness of the deck. To address this problem on future projects, the Structural Office, in co-operation with the Engineering Materials Office, is working to develop minimum standards for an existing deck that is to be waterproofed.

3.2 Material Quality

Due to forty-seven percent of material samples failing one or more test criteria in 1986, a decision was made to develop a price adjustment scheme for nonconforming materials. The various manufacturers were advised of their products' failures and also that a price adjustment scheme was under development. In March of 1987 a formal presentation was made to the Waterproofing Contractors Association outlining the proposed price adjustment system for membrane quality. The product manufacturers are members of this association.

Contracts awarded after August 1987 contain a special provision which adjusts price for both thickness and quality noncompliance.

Both waterproofing contractors and material manufacturers have complained that if a sample fails a test, there can be controversy as to whether the product was noncompliant as supplied or whether it was adulterated or damaged by overheating in the hands of the contractor.

Two manufactures have in fact claimed that noncompliance of their samples was caused by the contractor, and the manufactures have lobbied the Ministry to sample the material before it is put in the contractors melting kettle. The Ministry has refused, based on the fact that such a sample does not necessarily represent what is finally installed on the deck.

The manufacturers have been advised that since the contractors placing waterproofing on Ministry bridges are the manufacturers' approved applicators, it is incumbent upon them to ensure that those contractors handle and use their products correctly.

Contractors who are not confident in a manufacturer standing behind his product are free to seek out another one of the six sources presently listed in the Ministry's Designated Sources List.

Although not fully in effect in 1987, the fact that the Ministry has taken this price adjustment initiative, appears to have had a positive impact on the quality of material applied to bridge decks in that year. The percent of samples failing any test criteria dropped from 47% in 1986 to 20% in 1987. With the price adjustment in effect, along with greater manufacturer and contractor quality and process control, it is expected that a low percentage of future samples will fail.

4 FIELD DOCUMENTATION

4.1 Material Thickness

About 90% of the Waterproofing Membrane Thickness Reports contained errors or missing information. Errors were corrected prior to entry into the computer Some of the most common errors were:

a. Stages, rather than whole bridge decks, were divided into lots. This results in the same lot number appearing twice for one bridge.

b. The area of a stage or lot would be entered in the space for "Area of Deck".

c. The name of the membrane used was not recorded in the space for "Membrane".

d. Thickness results were recorded to one decimal place instead of to the closest whole millimetre. This results in an incorrect computation of the standard deviation and may also result in an incorrect mean value.

e. The standard deviation was incorrectly rounded off. It should be rounded to the closest 0.05. Incorrect rounding can make a significant difference in the determination of the payment adjustment factor.

f. The payment adjustment factor was entered as 0 or nil when it should be 1.0. This can lead to problems in determining payment for the lot when coupled with price adjustment for membrane quality.

4.2 Material Quality

Many samples were received without the Concrete Products Field Sample Sheet being adequately completed. Field staff should refer to the "Field Guide for Acceptance of Bridge Deck Waterproofing" to make sure that all required information is provided with the sample. This information is critical on contracts awarded after August 1987 which contain provisions for price adjustment in respect of membrane quality on a lot by lot basis.

5 CONCLUSION

The introduction of end result specifications for the acceptance of bridge deck waterproofing has had, and is continuing to have, the desired impact of improving the quality of this important item of work.